

Sense and sensibility: One of Kevin Delin's sensor web pods measures soil and climate conditions in a garden. The gray antennas let it communicate with other pods in a wireless network to relay and process data.



Casting the Wire



IDIDN'T KNOW THIS BEFORE, BUT PLANTS HAVE SEX," SAYS KEVIN DELIN. He's gesturing toward two huge cycads, palmlike fugitives from the Dinosaur Age growing in a corner of the Huntington Botanical Gardens, a sanctuary for 15,000 rare plant species in San Marino, CA. Delin's ignorance of botany is excusable. He's an engineer from NASA's nearby Jet Propulsion Laboratory, and what truly interest him are not the male and female cycads but the pair of "sensor web pods" lodged in the ground under the plants. Each pod is the size of a handheld computer and contains a processor, battery, solar cell, radio, memory, and sensors to monitor heat, humidity, and soil moisture. The pods are the surrogate eyes, ears, and even brains of the garden's curators, keeping track of how much sunlight and rain the plants are getting—critical factors for cycads, which need specific conditions to reproduce.

Sensors are nothing new. A car, for instance, uses dozens of them to monitor factors such as engine conditions. But the sensors in today's automobiles, factories, and office buildings are, for the most part, dumb. They lack the intelligence to analyze or act on their findings; instead, they send measurements back to a central processor. Most current sensors are also stuck in place, with any move requiring expensive rewiring. Delin's pods are different. They talk wirelessly with each other and with 18 other pods in the garden, forming their own intelligent network. Every few minutes, the pods update each other about their latest readings, together process the information into an overall picture of temperature and soil conditions, and send this analysis to the curators. It's as if an autonomous, highly aware computer were spread across 40 hectares of landscape.

"It's all about synthesizing global knowledge from raw data on the fly," says Delin. His pods foretold a future where smart sensors suck in vast amounts of vital data—say, mechanical stresses on the beams of a bridge, or the rumble of an enemy convoy on a moonless desert night—that currently go unrecorded. Wireless and battery-powered, such sensors will be accessed remotely and put where it would be impractical to string data and power lines. Small and cheap, they will be liberally distributed and closely spaced, yielding fine-grained pictures of phenomena such as climate that are currently charted only on a large scale. And because they will act cooperatively—organizing themselves and sharing computations across the mesh—they will provide people with usable chunks of predigested information rather than a confusing wash of numbers.

Indeed, wireless sensor networks are one of the first real-world examples of "pervasive" computing, the notion that small, smart, and cheap sensing and computing devices will eventually permeate the environment. That notion has been percolating in information technology circles for more than a decade. But now, after several years of research investments by the U.S. Defense Advanced Research Projects Agency, the National Science Foundation, and a handful of high-tech giants like Intel, the hardware and software fundamental to pervasive computing are emerging.

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Sensor Net

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